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MICROBIOLOGICAL ANALYZING METHODS FOR AEROSOLS

Live and dead microorganisms (bacteria, yeast cells, mold and others), located in the air, for the aeroplankton.

In the atmospheric air the basic mass of microorganisms form with the soil dust and the smaller droplets of sea water; in the air of closed areas(room etc.)--- with the room dust and droplets of saliva and mucous, dispersed by humans during conversation, coughing and sneezing. The interchange between the atmospheric air and the room air, through various openings between rooms and the outside, to a certain degree, reflects the dispersion of the bacteria in the atmosphere and in the air of enclosures.

The overwhelming majority of the microorganisms of the air are saprophytes; however, in the air in buildings, we more than once will find pathogenic microorganisms. Microorganisms are not encountered in the air in a free state; they appear, usually, in a fixed status in drops of fluid (saliva, mucous and others) or on hard aerosol particles. According to this information, it can be said, that the microbiological analysis of the air is the microbiological analysis of aerosols and, when they speak of the number of microorganisms in a unit of volume of air, we should understand this as the number of microorganisms fixed on particles of units of volume of a given aerodispersive system.

Some authors distinguish three phases in the bacterial aerosols: 1) the course-nucle r, consisting of course drops with a diameter of more than 0.1 mm, which are quickly settled from the air; 2) fine-nuclear, consisting of fine drops with a diameter of not more than

0,1 mm, which duratively remain in the air, are dispersed over great expanses and have the ability to deeply penetrate the organs of respiration during inhalation; 3) the phase of bacterial dust, formed by the drying of the course and fine drops and easily suspended in the air by the air currents.

In regard to the aerogenic infections, the fine-drop phase and the phase of the bacterial dust are the most dangerous.

The microbiological analysis of aerosols ordinarily leads to the bacteriological analysis of them; in some cases the micological analysis may prove interesting (fungus fever, mycos. of the lungs).

Sometimes, along with the microbiological analysis of aerosols, microbiological analysis of the aerosol particles, that is the aerogels, falling from the air, is conducted.

Below are set forth the bacterialogical and micological methods of analyzing the aerosols and aerogels.

BACTERIOLOGICAL METHODS OF ANALYZING AEROSOLS

During the bacteriological analysis of the aerosols, the determination of the general quantity of bacteria in a unit of a volume of aerosol (general dispersion)seldom limits the testing; such determinations are analogic with the determination of the microbe number for water. In a majority of the cases, besides the general dispersion, the quantitive characteristic of the microflora is determined.

Determination of the General Bacterial Dissemination of Aerosols

Many methods are suggested for the determination of the general dissemination of aerosols .

According to principals, forming the bases of these methods, they can be divided into 1) sedimentation, 2) filtration and 3) sorption.

The sedimentation method can be subdivided into the following groups: a) spontanious sedimentation, b) sedimentation stipulated by aspiration and striking against a surface and c) sedimentation stipulated by aspiration with a later electroprecipitation.

The filtration method can be subdivided into groups, depending on the character of the appropriate filter: a) filtration through membrane filters, b) filtration through filters from powder-like substances and c) filtration through liquid filters.

In all the said cases, the test is conducted on a level above the floor equal to the location of the openings of the respiratory system of humans; in factories— at the level of the height of a person, in class rooms— at a level exceeding the height of a table by 30-40 cm, in hospitals— at the level of the bed etc.

The tests are selected while there is movement in the room and when the room is quiet, this gives contrastive figures.

Of the large number of suggested methods, here are only the most important sedimentation and filtration.

Sedimentation Method

The sedimentation method is realized by allowing the aerosol particles to spontaniously fall onto a nutritious medium, or cause their fall by variation of some physical principal. According to the germination of the colonies on the culture medium, the quantity of bacteria in the air is concluded. Below are some sedimentation methods.

Spontanious Sedimentation Method

Petri Vessels with agar are placed at various points in the room and allowed to remain open for 5-10 minutes, then the vessels are covered and held at 37 degree C., in a thermostat, for 48 hours or at 22 degrees C. for 120 hours, after which the number of resulting colonies are counted, applying a computing chamber in case of neccessity. This method was suggested by Kokhom and is still used, but with adjustments. Here are some adjustments introduced by contemporary authors.

Because the quantity of aerosol particles, falling out onto the Petri vessels, depends to some extent on the direction of the air flow, P. N. Matveev reccommends selection of the tests simultaniously with 5 vessels, situated on a special sedimentary surface (wire frame). Of the 5 vessels, 4 are placed almost verticla with the surface of the ground or floor with the medium outside; the 5th vessel is placed on top, as if to cover the chamber formed by the other 4. The results are computed on an average of the count of all 5 vessels.

According to the author, this location of the vessels allows for the trapping of the aerosol particles traveling in any direction, horizontally or vertically. But the upward flow of air was overlooked here, this plays an important role in the pollution of the air, which indicates the neccessity of a sixth vessel, directed down with the medium under.

The Kokho method does not represent the volume of air, from which the aerosol particles fell out. Omelyanskii considers that on a platform 100 cm2, in 5 minutes, there will settle approximately as many microbe as can be suspended in 10 liters (0.01 m3) of air. For computation, they determine the surface of the vessels and tabulate

the quantity of bacteria into a singl. volume of air. The following is an example.

On a Petri vessel, which had been subjected to 5 minutes of exposition, there grew out 125 colonies. The radius of the vessel is 5 cm. If we apply the calculated data of Omelyanskii's, then the number of bacteria in 1 m3 of air is equal to---

$$\frac{125.\ 100.\ 100}{\text{pi radius } 2} \text{ equals } \frac{125.\ 100.\ 100}{2.\ 143.\ 25} \text{ equals } 15910$$

The above method is very simple; its disadvantage is that it does not give an exact determination of the number of bacteria in a unit of a volume of air, and therefor it can serve only as an orientattive analysis of the air.

The second disadvantage of this method is that the temprary exposure of the vessels(5-10 minutes) does not allow for the collection of a great quantity of any other form, other than the large particles of aerosols, therefor the calculation of the colonies of such vessels cannot serve as a criteria of the intensity of the bacterial sowing of the aerosols.

Method of Sedimentation Stipulated by Aspiration and a Blow Against the Surface

Of the given group, the methods of Shafir and Krotova are discribed.

Shafir Method

The principal of this method is, that the air being tested is aspirated through glass cylinders being rotated quickly; consequently the friction against the internal surface of the cylinders causes the

air to attain a circular motion. Under the action of the escaping centrifugal force, the particles suspended in the air, along with microorganisms, are discarded onto the internal surface of the cylinder, which is covered with an adhesive food medium (the principal of the blow), and here become fixed. The cylinders, with the adhering bacteria, are put in thermostats. The developed colonies are subjected to computation and, if neccessary, to differential testing.

The apparatus for the microbiological analysis of the air according to the above method, constructed by Prof. A. I. Shafir, is illustrated on graph 144. It is composed of a vertically placed electric motor(1), supported from three sides by rubber shock absorbers (2). A metal container is fastened to the shaft of the motor(3). A sterile glass cylinder is placed into the container (4). Under the base of the container there is a spiral conveyer of the electric ventilator. A removable metal housing(5) is placed over the metal container and the cylinder.

A metal air-conducting tube (glass may be used for more exacting work) is attached to the apparatus, this tube is tapered at the top and expanded at the base. Onto the tube there is placed a nut (7), a thrust collar (8) and a gasket ring(9). The tube, with the detailed fixtures is placed into the supporting ring of the jacket (10) and is tightened by the nut. At the upper end of the tube there is a sleeve, which, with the aid of a rubber tube, connects with the micromanometer (15).

Onto the frame of the micromanometer is screwed a gage, corresponding to the size of the tube used in the test. On the gage is shown the delivery of air in liters per minute. Two adjusting bolts (12) are used to level the micromanometer. A level is set on the frame

of the manometer (13). As an indicator fluid for the micromanometer, kerosine, tinted yellow with alkanna, is used. The indicator fluid is poured into the flask of the micromanometer in a quantity so regulated, that the menisc of fluid in the tubo of the manometer coincides with the zero (0) of the gage. The amount of air being directed into the cylinder is regulated by the slide valves located in the cover of the jacket.

The wider the valves are opened, the less the amount of air is drawn in through the axle tubes and the reverse. The flow of air can be regulated from 12 to 40 liters per minute.

Calibration of the micromanometer can be accomplished with the aid of a rheometer, connected to the outside vent of the axle air-conducting tube.

A test with the above apparatus is conducted as follows: The jacket, together with the air-conducting tube, is removed from the metal container. 20-25 ml of the culture medium are placed into the vylinder. The medium has been priliminarily cooled and liquefied. The motor is started and then the jacket is replaced. The liquid culture medium rises along the walls of the sylinder, due to the rotation of the cylinder, distributing a layer 1.55 mm thick.

The motor should operate for 10 minutes for each test. The bacteria from the suctioned air is thrown onto the adhesive surface of the culture medium and is fixed here.

After the test, the glass cylinder is removed and placed into a thermostat, bottom up, where it dries. Then the cylinder is covered with a sterile cotton stopper and is placed into a closet for developement of the colonies. A sarcopeptone agar is used as the

culture medium during the quantitive innumeration of the microbes of the air. For the analysis (qualitive) of the microflora of the air, a corresponding elective medium is used: for hemolitical streptococcuss-- blood agar, for B. coli--- the Endo medium etc. Seperate colonies can be extracted from the cylinder and transplanted on a corresponding medium.

The counting of the colonies grown in the cylinder, and if there are not too many (200-300), are conducted fully. During an abundant growth, a circular form is utilized for counting (14); in this form are square apertures. A count is made of the colonies in 15-20 of these squares and then an average is determined.

Knowing the measurements of the surface of the squares of the form and the internal surface of the cylinder and considering the amount of air let through the apparatus, it is possible to determine the number of microbes in 1 m3.

Example: 250 liters of air passed through the apparatus. The average number of colonies in one square was 28. The surface of the square of the form is 4 cm2, and the internal surface of the cylinder is 195 cm2 (height 170 mm and diameter 150mm). The number of microbes in 1 m3 of tested air is:

$$\frac{28.\ 195.\ 1000}{4.\ 250} \text{ equals } 5460$$

The discribed apparatus traps far from all the microorganisms in the air. According to some data, its effectiveness is 72-76%, and by other data lower. The small particles of the aerosol are poorly trapped however.

The shafir apparatus has and is utilized in Soviet Medical Industry.

The Krotova Method

The apparatus of U. A. Krotova (graph 145) consists of a cylindrical body (1), to the base of which (2) there is secured an electric motor (3). To the axle of the motor there is attached a centrifugating ventilator (4), in which there is located an eight-bladed impeller (5). To the flange of the axle of the impeller is secured a disk (6) with three springs (7), with the aid of which the vessels (8) are fixed, resting on the disk (6). The form of the apparatus is covered by a hermatic jacket (9), which is tightened down by three cast on locks (10). Into the cover is placed a plexiglass disk (11), having a radially positioned cuniform aperture (12). The disk is secured to the vessel by various rings (13) with threads.

In the center of the base of the apparatus there is a sleeve with a diaphragm (14), to this sleeve is attached a rubber draw-off tube (15). The apparatus operates on both 127 and 220 volts.

In operation, the ventilator rotates at 4000-5000 rpm., which causes an energetic aspiration of the air; the turbulent flow of air, rotating the impeller (5) stipulates the rotation of the disk (6), to which is attached the Petri vessel. The disk rotates at 60 rpm., which insures an even dispersion of the microbes over the complete surface of the medium.

With the aid of a switch and a rheostat, the flow of air through the apparatus can be regulated from 25-50 liters per minute (l/min). The volume of air is determined by a monometer similar to the one used with the Shafir apparatus.

U. A. Krotova claims his apparatus catches twice as much air as the Shafir apparatus and twice as many microbes in a unit of a

volume of air. This apparatus also eliminates the need of glass cylinders because the microbes are caught in the Petri vessels.

The Krotova apparatus is also utilized in Soviet Medical Industry at the present time.

Filtration Method

The filtration method consists of drawing a certain amount of air through a sterile cloth filter or a sterile fluid medium and then using the filtered out material for the cultivation of bacteria. The number of colonies resulting are the bases of the quantity of bacteria suspended in the air, and the results are computed to a unit of volume.

Mironov Method

The filter is prepared from a filter paper and, in the form of a cone, is placed into an adapter with a diameter of 3 cm. The edge of the filter is curled down over the edge of the adapter and held in position by a rubber ring. The air is suctioned at the rate of 500-700 liters an hour. The filter is then placed into a sterile jar with glass balls ~~//~~, then 50 ml of sterile water is added and all this is agitated. The obtained suspension is the material for the determination of the bacteria by sowing on a culture medium.

The Milyavski Method

The author uses membrane nitro-cellulose filters (No. 3), which have been used for a long time in the bacteriological analysis of water.

It is neccessary to note that E. Dianova and A. Voroshilova, using membrane filters for the analysis of water back in 1932, first expressed the possibility of using these filters for the bacterial-ogical analysis of the air.

The membrane filters are boiled in water for sterilization, are dried and placed into the Zeitsta apparatus with the shinny surface to the net. The air is suction through the filter at 5 liters per minute for 10 minutes, or a total of 50 liters.

A rheometer (graph 146) between the apparatus and the pump is used to gage the speed of the air being suctioned.

To ascertain whether or not there is any bacteria escape during experiments, a cotton stopper is placed into the neck of the apparatus. The apparatus is sterilized before use. After the test, the cotton wad is planted in a bullion. If there was no passage (escape) of bacteria, then there will be no growth.

After the filtration, the membrane filter is placed, shinny side down, onto 1% agar in a Petri vessel. The agar has to be cooled before the sowing of the filter sufficiently to avoid formation of condensation of the humidity with the seperated vapors. The vessel is placed in a thermostat for 48 hours.

The membrane filters, according to the author, insure the developement of various saprophytic forms of microorganisms from the air, able to grow on a meat-peptone medium; in this number are the sporidiferous and pigment type.

If the filters are sown in a special medium, corresponding to the given type of microbe, than there can be insured the developement of pathogenic microorganisms, filtered from the air.

Stamps on various mediums can be prepared from the filters.

Thus, the membrane filters make possible not only the obtaining of quantitive, but also qualitive characteristics of the microflora of the air.

Because groups of bacteria can be sown on certain sections of the filter, forming unitary colonies during growth, then the number of resulting colonies are far from coinciding with the number of microorganisms sown.

This is why the author recommends the washing of the filter with 15 ml of physiological solution to insure a full-value count. The washed filter must be sown seperately, and the fluid, used for washing, should be filtered through several membranes which also are sown. The results of the count of the developed colonies on all filters are summarized.

Dyakonova Method

The apparatus (graph 147) consists of a cylinder, into which are put a few glass balls and 30-50 ml of water (bullion). The cylinder is covered with a stopper, through which pass two tubes; the incoming reaching almost to the bottom and the outgoing ending under the stopper. The tubes are secured in place with cotton wads. A co ntrolling cotton plug can be placed into the horizontal bend of the lead-out tube. The apparatus is sterilized. All the cotton wads, except the controlling, are removed from the tubes. The air is suctioned as shown by the arrows in graph 147. After the test, it is necessary to duratively and carefully shake the contents of the cylinder, after which a sowing is made.

The Shtrauss Method

In those cases when the content of microflora in the air is in significant, then it is recommendable to filter the air directly through the culture medium. The Shtrauss apparatus (graph148) can be utilized for this purpose. It consists of a cylinder (a), tapered towards the bottom; from the side of the cylinder protrudes an outlet (b). Into the cylinder is placed a ground pipet (c). During testing the apparatus is placed into warm water (37-38 C.) to a depth of half the height of the apparatus, and into the cylinder is put a liquefied gelatin, an amount equaling half the volume of the cylinder. A determined volume of air is suctioned through the gelatin, joining the side outlet to a rheometer, and the latter to an aspirator. After the test the gelatin is spread evenly over the inside of the cylinder and in this form is placed into a thermostat at 22 C. for 5 days, after which the resulting colonies are counted.

Determining the Qualitive Characteristics of the Microflora of the Aerosols.

The determination of the characteristics of the microflora of the air can pursue three problems: a) the determination of the sanitary-indicative microorganisms, b) the determination of the presence of pathogenic microorganisms and c) the determination of the presence of fungus microorganisms.

The determination of the presence of fungus microorganisms is realized through mycological analysis of the aerosols.

Determination of the Sanitary-indicative Microorganisms

Under the sanitary-indicative microorganism we understand those microorganisms, the presence of which in a given medium (air, water and others), indicate the determination of the origin of pollution.

Mironov suggests, for the determination of the presence of sanitary-indicator microorganisms in the air, analysis of the air for the presence of sporiforous microbes; B. coli, anaerobes of the perfringens group, B. proteus and streptococcus. The sporiforous microbes, related to the soil microflora, indicate the pollution of the air by soil dust. A large quantitiy of B. coli in the air indicates contamination of the air with dust containing excrement. Anaerobes of the group perfringens also indicate dust of a fecal origin in the air. A find of a large quantity of B. proteus indicates the pollution of the air by products of decomposition of a septic nature. Finally, the presence of a large quantity of the streptococcus points to the contamination of the air by the exhalations of the upper respiratory tract.

A. I. Shafir and others suggest considering the streptococcus viridans and streptococcus haemolyticus as indicators of the bacterial pollution of the air; these streptococcus are common inhabitants of the human nasalpharynx. The author believes that these streptococcus can serve as indicators of the pollution of the air, much as the bacteria of the intestinal baccilli group serve as indicators of the contamination of water.

A. I. Shafir considers that less than 16 streptococci (viridans and haemolyticus in aggregate) in 1 m3 of air of an unventilated room, during the summer, and 36 in the winter months, indicates fairly clean

air. The detection of 36 streptococci in the summer and 124 in the winter, in 1 m3 of air, indicates pollution.

The seperation of any of the microbes from the medium, in which the microflora of the air was caught, and their identification is conducted by respective microbiological techniques; sowing on an elective medium, study of mobility, morphological, tinctorial, cultural, biochemical and virulent substances. The recommended techniques of these determinations are identical with those on Pages 261-264 and will not be described here(Above pages not translated.).

We refer to the method of determination of the haemolyticus streptococcus in the air according to P. F. Milyavski. This method is described in literature, but as yet has not been included in the manual.

Determination of Pathogenic Microorganisms

In room air there were simultaneously found pathogenic microorganisms: B. tuberculosis, B. dyphteriae, Staphylococcus pyogenes, Streptococcus pyogenes, spores B. anthracis, B. tenani and others. This undoubtedly indicates the possibility of aerosol infections (dust and droplet infections).

In regard to the detection of pathogenic microorganisms in the air, it is necessary to make the following notations: a) during the determination of the pathogenic microorganisms in the air, the quantitive indicator does not play an essential role; it is adequately certain that the detection of one pathogenic microorganism in the air indicates the presence of an origin of infection, b) the non-detection of pathogenic microorganisms has only a relative value because of the insignificant quantities of pathogenic microorganisms in the air the relative difficulty in detecting them and c) the above mentioned lack of a

concentration of pathogenic microorganisms in the air dictates the necessity of searching for them in large volumes of aerosols.

Relative to what was said in point b), it is expedient, during the analysis of the air for pathogenic microflora, to utilize apparatuses which allow the filtration of large quantities of aerosols through the bacterio-collecting mediums. Of these apparatuses, we can suggest the apparatus of Rechmenski (graph 149).

The apparatus- aerocentrifuge consists of a disk (a), secured to the axle of the electric motor of a fan (room ventilator) (b), from which the blades have been removed. On the disk are secured fourn curved glass tubes (c). The form, size and location of these tubes are analogical with the blades of the centrifugative hydroturbine of Frenzis. On the inside surface of the tubes are placed plates of cellophane, which are smeared with vaseline. The apparatus is equiped with a rheostat (d) for regulation of the rotation speed of the disk. Upon rotation of the disk, the air enters the tubes; the aerosol particles strike and adhere to the cellophane. The sowing of the microflora plates is done by impressing them intc an elective medium. The described aerocentrifugal apparatus was utilized with success in practical conditions.

The method of seperating and identifying the pathogenic bacteria, collected from the atmosphere, is not written up here.

Mycological Methods of Studying Aerosols.

As was pointed out above, the fungus, encountered in the air, can stipulate an infection such as pulmonary mycosis, fungus fever and others. The infection arises, evidently, only in those cases when the fungus is in the air in massive quantities, arriving there together with the aerosol particles.

The method of determination of the fungal flora in the air, as with the determination of the bacterial flora, is composed of three stages: collection from the air, cultivation on a medium and lastly, identification. Collecting of the fungal flora is accomplished the same as with bacterial flora.

Relative to the last two stages, it is necessary to say the following: the fungi grow well on various mediums, however, the morphological ability of the fungi can vary according to the consistency of the medium. Therefore, for the obtainment of a consistent identification, the medium of Saburo is usually used in the following consistency: agar 1.8 gram, peptone 1 gram, maltose 4 grams and distilled water 100 ml. A similar quantity of glucose can be used instead of the maltose. For durative conservation of the culture, it is necessary to remove the carbohydrates from the medium to avert the degeneative variations in the growth (pleomorphism).

On the Saburo medium, the Aspergilius fumigatus forms dry fluffy colonies of a greenish-brownish color, which, with the development of fertility, acquire an appearance as if covered with flour; the Penicillium form flat velvet colonies of various colors; Mucor gives colonies having the look of fluffy formations. The optimal growth is accomplished at a temperature of 26-28 C.

The identification is conducted mainly on the results of the microscopic studies; detectors are utilized during this.

Often it is valuable to analyse for the presence of those fungi, not aerosols, but those objects which could have served as the origin of the air pollution; grain, rags, etc. (267-270).

Discussion and Summary

In the USSR, to this time, there has not been accepted any standard method of determining the bacterial contamination of the air.

The numerous methods, described by many authors, on the study of the bacterial flora of the air suffer substantial deficiencies. This is in respect to those methods which are directed to the determination of the intensity of the bacterial contamination of the air (the general quantity of microorganisms in a unit of a volume of air and the determination of the number of sanitary-indicative bacteria in a unit volume of air). To a lesser degree, this is true of those methods of detecting the pathogenic microflora, where the quantitive indicator does not play a great role.

The basic deficiencies in the determination of the intensity of the bacterial pollution of the air are, in our view, the following: a) regarding the method of spontaneous sedimentation- the question of the volume of air, from which the bacteria is falling out, is not certain and also, many times the bacteria does not succeed in settling in the short-time exposure and escapes counting; b) regarding the sedimentation method stipulated by aspiration with percussion against a surface- the disruption of the physical structure of the aspirated aerosol particles and besides, there is not a full collection of the bacteria; c) regarding the filtration method- the greatest deficiency lies in the disruption of the physical structure of the aerosols during aspiration.

In our view, tests of durative sedimentations of the bacteria from an isolated volume of air (with an apparatus of the Owens-II type, large size) or short timed tests of sedimentation, stipulated by electroprecipitation (in apperatuses of the type know as the

electroprecipitator of Truhanov) would be interesting and the possible solution to the question of the intensity of the bacterial contamination of the air. A slide, with culture medium on it, serves as the bottom of all these apparatuses

Microbiological Methods of Studying Aerogels

For the microbiological study of the aerogels, it is necessary to take a weighed portion of a given type of aerogel. This is attained by a collection of the aerogels from walls, mouldings, floors, furniture and other items by using a sterilized cotton tampon or a sterilized small brush and removing the aerogels into a preliminarily weighted sterilized glass. The aerogel so removed is weighted and placed by quantity into a cylinder, in which are placed glass balls and a specific amount of a physiological solution (bullion).

To insure an even spreading of the aerogel particles in the fluid, it is shaken (not less than 200 times) and agitated by the glass balls in the cylinder. The suspension obtained is sown on Petri vessels, which contain a culture medium. On the basis of the calculation of the colonies, they make a conclusion of the degree of sowing of the aerogel. They thin the suspension when necessary.

Example; A suspension was prepared from 1.4 grams of dust in 100 ml of physiological solution. Various dilutions were prepared from this suspension and sown on agar in 1 ml quantities of a 1:10 solution. The number of resulting colonies were 28. From this we conclude that on 1 gram of aerosol there takes place:

$$\frac{28 . 100 . 10}{1.4} \text{ equals } 20000 \text{ microorganisms.}$$

The qualitive as well as the homologous characteristics of the microglora of the aerogels are obtained.

Methods of Studying the Entrance of Aerosols into the Organism of Humans during Breathing

Here we do not intend to write up the methods of studying the pathologoanatomical, pathologophysiological, biochemical and physicochemical variations which occurr in an organism, stipulated by the inhalation of one or another aerosol. These questions go beyond the limits of this book. We intend to explein that method which will enable the deriving of a judgement of the dispersive phase of the aerosol during their entrance into an organism. The following questions well be written on: 1) determination of the weight quantities and degree of disperaability of the dispersive phase of the aerosols inhaled by humans; 2) determination of the retainment of the dispersed phase of the aerosols in the respiratory tract and lungs upon inhalation; 3) determination of the solubility of the dispersed phase of the aerosols in the fluid of the body. In conclusion we will set forth several physiological acts (conversation, coughing, etc.) and the medthod of conducting a biological experiment in the aerosol field.

Determination of the Weight Quantities and Degree of Disperaability of the Dispersive Phase of the Aerosols Inhaled by Humans

a) Determination of the weight quanities.

The quantity of dust inhaled by man under various circumstances has interested many authors for some time. These quantities were

ordinarily considered on the basis of the determination of the weight concentration of dust in the air; by this we understand that a man inhaled 400-500 liters of air in one hour average.

Thus, Gesse, on the basis of the results obtained by him, calculates that in a years time a worker inhales:

Location...	Grams of dust......
Mill	71.55
Weaving plant	4.5
Paper Mill	37.35
Hat shop (factory)	9.63
Iron-works plant	150.0
Bristles plant	6.4

According to Arens, the workers inhaled in a similar length of time as follows:

Bristles plant	15.0
Sawmill	27.0
Fur factory	37.0
Iron-works plant	42.0
Snuff factory	108.0
Cement plant	336.0

Of the Russian authors, Okunevski agrees with this method of calculating the quantity of dust inhaled by man.

The described calculations would be correct if the aspirating apparatuses and all the situations in general would fully imitate the activity of the respiratory apparatus of humans, especially in

regard to the suctioning of the air. In reality, such apparatuses are not utilized in determining the dust in the air; this is the reason there have been deficiencies in the determination of the inhaled dust.

Let us analyse the simplest features of the action of the human respiratory system in regard to the aspiration of the air, in contrast to the action of those apparatuses of aspiration used in the quantitive determination of dust.

The respiratory action af a human, as is known, is realized through the nasal appertures. Only in those cases where the passage of air through the nose is obstructed (swelling, inflammation, etc.) is the air deverted to the mouth and nose or the mouth alone.

The nasal apertures have a cross section of 1.5-2 cm2 and are usually directed down.

Each inhalation and exhalation involves about 500 ml of air. In the course of a minute, on the average, a person makes 14-16 inhalations and exhalations; the exhalations are accomplished slower than the inhalations, so that the relation of the period of exhaling to the period of inhaling $\frac{(ex)}{(In)}$ is equal to two on the average.

The respiratory variations of the pressure of the air in the nasal area is a negative pressure of 9-10 mm of a water column during inhalation and a positive pressure of 7-8 mm during exhalation.

During physical strain the venilation of the lungs is definitely increased, and instead of 8 liters a minute, a person can inhale 30-35 liters of air; the amplitude of the respiratory variations of the pressure of the air in the respiratory tract also increase at this time.

We established, by experimental means, that forceful respiration can attain a negative pressure of 100-120 mm of a water column during inhalation and a positive pressure of 80-100 mm during exhalation.

Therefore, to characterize the aspirational action of the respiratory apparatus of man, we must keep in mind: 1) the direction of the nasal apertures; 2) the size of the cross section of them; the quantity of air inhaled at one time; the negative pressure developed in the nasal area during inhaling; 3) alternation between inhaling and exhaling and 4) the variation of the ventilation of the lungs relative to the work.

The direction of the nasal apertures during the suctioning of dust has the following meaning: the falling dust particles, located near the nasal apertures at the moment of entrance, are subjected to two forces, which are gravity and the suctioning action of the respiratory system. The fate of this or that dust particle will depend, as we see it, on the equality of these two forces. Therefore, only those dust particles whose weight forces are exceeded by the suctioning forces will be carried into the respiratory system.

This reasoning is in regard to the first two types of dust of the Jibbs classification. Dust particles of the third type, with diameters of 0.1 micron and smaller, located in a constant Brownian movement, can be carried into the respiratory tract with very little suctioning action and even without any. But, because of the small size of these particles, they do not have any serious importance in the calculation of the weight quantity of the dust inhaled by man.

The above reasonings can also be useless in those cases where the dust travels sideways from a given origin, up and/or down. But even in these cases the angle of the nasal apertures is important in determining whether or not the dust particles will be carried into

the respiratory system of man by the suctioning force, or voluntarily by the air movements.

The greater the negative pressure is, the more the ceteris paribus-quantity of dust inhaled into the lungs will be, and the reverse.

The alternation between the inhaling and exhaling, which could influence the quantity of dust inhaled, comes to this; after the suctioning action carrying the dust particles in during inhaling, there is a repelling force of these same particles during exhaling.

Thus, thedetermination of the flow of air, affecting the amount of dust inhaled, is stopped at the outer respiratory tracts of man.

The variation of the action of the respiratory apparatus of man while working also is important in regard to the amount of dust inhaled, because the variation of the ventilation of the lungs is accompanied by a variation in the pressure of the air in the hasal area and consequently, in the amount of dust suctioned in.

Having given a short review of the action of the human respiratory apparatus as an aspirator, let us review concisely the action of those apparatuses which are utilized often during the quantitive determination of dusts, and namely, the Petri pump, bellows, water-jet pump, cylinder and reversible aspirators.

The action of the apparatuses was determined with a cotton filter attached to the apparatuses. The connecting rubber tubes had a diameter of 10-12 mm and an average length of 1.5-2 m. The negative pressure of these apparatuses was determined by a water manometer. The speed of the suctioned air was determined by a catathermometer, and as Table 16 shows, the speed of the air movement, determined by the catathermometer, follows the negative pressure, increasing and

decreasing with it according to theoretical considerations. The determination of the action of the apparatuses was made in comparison with the action of the respiratory apparatus of man.

Table 15 shows that there are variations between the actions of the apparatuses themselves, and between the apparatuses and the respiratory action of the human organsm.

This undoubtedly is true of many other apparatuses used in the quantitive determination of the dusts in the air.

The discribed characteristics of the action of any of the devices, with extensive conclusiveness, indicate into what group of errors the above authors are placed, relative to the determination of the quantities of dust inhaled by man.

More significanly, exact data can be obtained by physiological aspiration methods, using the human respiratory apparatus as the suctioning device.

But here we must make a limitation: the physiological method of aspiration cannot give exact data on the quantity of dust inhaled by man because, using any device for the aspiration of the air through any filter, we dispupt the normal breathing in rhythm and depth, which should, by the nature of things, reflect on the quantity of suctioned dust.

All the physiological aspiration methods respresent some interest and value according to the following: as all other methods, it can give material for the comparative evaluationf of the dust-pollution of the air, while at the same time, this material can be utilized for conclusions of the approximate quantities of dust inhaled by man, very valuable relative to toxic type dust.

Arnoldov, Lemann and others applied the physiological method of aspiration .

Considering that this method was not sufficiently developed and verified, we tried to improve on it.

We constructed a device, illustrated on graph 150, which consists of three parts. Part A is a glass tube 7 cm long. The inlet opennings have a cross-section of 2 cm2 and are directed dowin. Three such tubes belong to the apparatus. The tubes and respective covers for them are numbered. A filter is placed into these tubes. Part B of the apparatus is also a glass tube, but shorter than the tube A, and this tube ends in a chamber, from which lead two tubes 8 mm in diameter.

Tube A is tapered and fits into tube B tightly, at a distance of 2.5-3 cm.

The third component of this apparatus is C, composed of two nasal adapters,with cup-like apertures which fit the nostrils on one end and tapered on the other end to fit into the outlets of part B, where they are held in position by rubber sleeves. An adjusting, sliding band holds the device in position during testing (graph 151). This band attaches to another band which is positioned on the head of the subject like a cap and holds the device up. A filter is smeared with vaseline and attached to tube A. When using this device, it is necessary to inhale through the nose and exhale throught the mouth. The testing should last to one hour. The filter is weigthed before tests began.

The tests can be conducted on experimental personnel or on laboratory workers. The filters are again weighted and the difference in the weights is the amount of dust. The results are calculated to units of time.

The three A type tubes aid in conducting repeated tests or tests in different sections of a room and at different times.

We tried to suction the air via the mouth, but the results were unsatisfactory because the air enters the nose also, which cannot be controlled or closed because it is used to exhale this same air. To the time of this writing, the most recommendable type of device to use is the nasal type. The filters can be of cotton cloth or cotton paper. Both give fair results.

Discussion and Summary

The question of the weight quantity of dust inhaled by man, having an important meaning relavtive to the harmful type dusts, cannot be answered by the ordinarily applied methods of weight determinations of dusts.

Most of the aspiration methods now used for the weight determinations are far from representing the actual human system of suctioning, and therefore we cannot make any conclusions on the quantity of dust inhaled by man.

The data obtained by sedimentation methods are even more uncertain than those obtained by aspiration.

The same thing applies to the photometric methods used for the determination of the weight concentration of dust in the air. They are approximate in this respect, but in measuring the amount of dust inhaled by man, they are poorly regarded.

Therefore, the author believes that the best method is the filtration method, using devices to filter the air, but using the human respiratory system as the aspirator.

b) Determination of the degree of dispersion.

The following method was applied by Vigdorchik and Petrov for the solution to this problem: A small polished round cover glass, smeared with a fixing medium, was inserted into the nose of the person being used in the test. The glass was removed after an hour and carefully studied under a microscope for the size of the particles. The degree of dispersion was calculated from the results. The tests were conducted with indiviuals doing light work. Table 17 gives the results of two types of dust.

The table shows that in 99% of the cases the size of the particles was no higher than 5 microns and a small quantity of the particles had a size of from 5-10 microns (1%). There were no particles with a diameter of over 10 microns.

The above results are supported by those obtained by Petrov and Anchutina during their study of mucus, taken from men working in dust. Less than 1% of the mucus, according to the authors, was incorparated with particles of over 10 microns.

It is undoubtable that during heavier work, when the respiratory system increases the suctioning action, that larger particles do enter the organism, but this problem needs further study.

Determination of the Entrapment of the Dispersive Phase of Aerosols in the Respiratory Tract and Lungs during Breathing

A certain amount of the aerosol particles, inhaled through the nose, remain in the nose. Lemani estimates this at 5-80%. Such a large quantity is attributed to the peculiar abilities of the nose to filter the air. Other authors quote the figure as being lower—30-[illegible]% and no higher. The degree of dispersion of the aerosol plays

an important role in this question. E. A. Vigdorchik showed that the filtration ability of the nose, relative to highly-dispersive smoke, such as smoke of coal, tobacco and magnesium, is so negligible that it escapes determination.

The aerosol particles which enter the nose and the lungs, depending on their size, rarely exceed 5 microns.

A small percentage (average 10%) of the aerosol particles are expelled with the exhalation force. Some are expelled with the nasal mucus and others enter the food tract.

For the determination of the quantity of aerosol particles, inhaled and entrapped in the respiratory tract, they usually use the following method: . in a dust chamber they create a determined, and as much as possible stable, concentration of some aerosol. They determine either or both, the weight and particle concentration of the inhaled and exhaled air. From this is calculated the weight or particle quantity of dust retained in the respiratory system.

When the dispersed phase is in a drop-liquid form, they use chemical methods for the determination. Following are some methods.

The Method of Vigdorchik and Petrov, For Aerosol Particles of the Higher-than-Ultramicron Order

The principal of the method is: with the aid of an Owens-I meter, there are collected specimen of the inhaled and exhaled air; computing the results of the count and determining the dispersion of the aerosol particles of any test, it is possible to conclude the quantity of particles entrapped in the respiratory tract and lungs.

To enable the selection of testing either the inhaled or exhaled air, the authors constructed the mask illustrated on graph 152. On the

flat surface at the bottom of the mask are two apertures, both leading into valves. The valves N and N-1 are cylindrical tubes into which are placed the mica discs M and M-1. Upon inhalation both discs rise; disc M lets in the air through valve N (inhalation valve), while disc M-1 intercepts the flow of air through valve N-1 (exhalation valve). The reverse is true upon exhalation. To conduct a selection of specimen of the air from the mask with the Owens-I device, a tube (K) is soldered to the front surface of the mask. The tube is 30 mm long and 20 mm in diameter. On the flat front surface of the tube are two apertures n and n, 8 mm in diameter. The apertures are opened and closed by a rotating disk with two holes. The subject wearing the mask controlls this to furnish either inhaled or exhaled air. The Owens-I meter is connected to the tube K. The sample of air is taken at a distance of 3 cm from the mouth. The sample is usually taken after the 9th exhalation after doning the mask, this allows for clearing the mask of fowl air etc.

The subjects wearing the masks in the tests preliminarily acquaint themselves with the mask and breathing through it so as to afford the most normal conditions.

The following dusts were tested: room, quartz,coal and tobacco. The latter three were created and tested in chambers, one of which is described below.

As a result of their tests on two subjects, the authors come to the following conclusions: 1) the larger the particles, the more they became entraped in the respiratory system and lungs; the percentage was fluctual from 12.8 for room dust to 47.1 for tobacco dust; 2) the physicochemical peculiarities of the dust do affect the degree of their

entrapment; coal dust was entrapped most in both subjects, this being for fractions below 1 micron; 3) the comparison of the entrapment during mouth and nasal breathing indicated that the general percentage of entrapment in a majority of the cases is more during nasal breathing, but for particles of less than 1 micron, no regularity exists.

Vigdorchik Method for Aerosol Particles of the Ultramicron Order

The principle of the method is as follows: The smoke particles in the inhaled and exhaled air are computed with a meter and a calculation of the difference gives the amount of entraped particles, occurring during the breathing process.

The tests were conducted with smoke obtained from buring tobacco, lump coal and magnesium. The concentration of particles for smoke was from 65,000 to 375,000 particles per ml for tabacco, 45,000 to 310,000 for coal and 65,000 to 300,000 for oxide of magnesium.

An apparatus, constructed for the test, is illustrated on graph 153.

The subjects in the tests used the M mask which adapted to the face with an obturator. In the lower section of the mask were two mica valves; one for inhaling and one for exhaling. Directly across from the mouth was a diaphragm which could be opened or closed upon inhalation or exhalation by the subjects. The mask was secured to a support, which was in turn secured to a table.

The authors utilized two computers for the computation of the smoke particles. One for the inhaled air and one for the exhaled air. On graph 153 the designates U-1, S-1 and O-1 are the microscope drain grooves

and condensers for the computation of the ultramicrons of the inhaled air; U-2, S-2 and O2 are for the exhaled air; H1- valve, by which air samples were taken from the chamber K, H2-valve which directed air into mask. The aspiration of the air to the drain channel S 2 was done with the aid of an aspirator (not shown on the graph) through the rheometer E. The aspiration of the air into the mask was done by the inhaling of the subject. The exhaled air was partially released through the mica exhalation valve, and in part through the connecting tube D, into the the drain channel of the computer of the exhaled air S1; during this test the subject opened the gate valve at the end of each inhalation, opening the path for the exhaled air to the computer. The electricity for the lighting was obtained from the transformer T, which realeased up to 11 volts. The above apparatus also had an adapter to control the temperature of the exhaled air in the tube D. This was done with an electric current to the tube D and drain channel S1, with the heat regulated by the rheostat R. This was done to avert concentration of the smoke during its passage through the tube D and drain channel.

A differential thermo-element (t) was used for the control of the temperature; one junction was in the mask and the other at the exit of the drain channel. The tests were conducted at a zero position of the pointer of the galvanometer G, that is, at one and the same temperature air in the mask and in the drain channel. With the aid of the above described equipment M. A. Vigdorchik established that the smoke of tobacco is entrapped in various persons at a 64-76% average, lamp coal- 54-74% and smoke of oxide of magnesium- 62-77%.

The above method does not offer the possibility of establishing what portion of the highly-dispersive particles penetrates into the

deeper sections of the lungs because the entrapment could take place in the walls of the respiratory paths, as with inhaling, so with exhaling. One defficiency of the method is the irregular, by characterestic and by intensity, aspiration of the air from the chamber directly into the mask and drain channel. The other defficiency is the unevenness of the air falling into the channels S1 and S2. In the second case (channel S2) the path of the air through tube D and also through the mask may cause the entrapment of some of the particles on the walls of the tube D and Mask.

Determination of the Solubility of the Dispersive Phase of Aerosols in Liquid of an Organism

The question of the solubility of the dispersed phase of the aerosol in the liquid of the organism possesses an especially importen meaning when work is being done with toxic type aerosols, because the degree of solubility predominately determines the degree of absorption of the substances from which the aerosol is composed.

A suggested method for such a determination follows; a determined weighed portion of an aerosol, selected from the air by any means, is dried to its constant weight and subjected to the action of some solution; a physiological solution impregnated with carbon dioxide for the lungs; saliva, intestinal and gastric juices for the gastrointestinal tract; blood serum etc.)....This mixture is left for a certain interval at 37 C., agitated from time to time. Then the mixture is filtered through an ordinary filter or through a Guch filter, preliminarily weighted. The residue on the filter, which is rinsed with small portions of distilled water until the solution is washed away, is dried

together with the filter to the constant weight and weighted. The difference between the regular weight of the filter, the weight of the filter after the test and the weighted portion taken for the test compose the weight of the dissolved portion of the original weighted portion.

If one considers that the solution is not fully washed away by the distilled water, then it is necessary to conduct a dry test under the same conditions, but with-out an aerosol, or with a known non-dissolving aerosol (charcoal), and determine the corrective needed in the results of the analysis. The relation between the weight of the aerosol being tested and the weight of the solution should be varied (1:100, 1:200, etc.) so as to clarify the degree of solubility.

The one possible objection to this method is whether or not the rinsing of the residue on the filter with distilled water increases the quantity of substances which go into the solution. This may be so, but in a small degree only.

The weight of the dissolved substances can be determined in another way: determine it in the solution by weight, volume or colorimetric means. If the weight method is used, then it is necessary to determine the solid residue of the solution by a dummy test and then enter a respective corrective.

For some data on the solubility of aerosols in water see Table 13. Data obtained by the method of determining the solid residue in the filter.

We analysed the solubility of tobacco dust in the fluid of an organism by determination of the solid sub stances not entering into the solution and found that solubility reached 30% (average). In saliva it was 25%, in stomach juice 35%, in the intestinal juice 32% and in

in a physiological solution impregnated with carbon dioxide- 30.5%.

I. S. Shereshevskaya analysed the solutility of free silicon dioxide (finely ground quartz, opan and sedimentary silicon dioxide) in water solutions and human serums. The water solutions were employed with pH-6.0, 7.0 and 8.0; solutions with pH-7.0 and 8.0 were prepared from boric acid, potassium chloride and alkali; in the place of the agent pH-6.0, there was used distilled water, which gave a specified concentration of the hydrogen ions

The tests were conducted through various intervals from the start of the observations. The dissolved free silicon dioxide is determined in the filter by colorimetric means.

The author came to the following conclusions, based on the data of his studies: the solubility of quartz is increased with time and with the increase of the concentration of the hydrogen ions of the solution. Near the end of the first monthe the solubility reachs a certain level, which it holds for six months (the period of the authors observations). For the solution with pH-7.0 and 8.0 the saturated solubility of quartz is equal to 1 mg to 100 ml of solution. The solubility of opal and sedimentary silicon dioxide proved greater then the solubility of the quartz. In solutions of serum of blood of humans the solubility of the quartz and opal was higher then their solubility in solutions with a concentration of hydrogen ions, specific for such a serum.

Shereshevskaya included one other problem in her studies. As electromicrosconic studies indicated, the silicon acid, forming with SiO_2 solution, can exist in the solution in tow consistencies: 1) molecularly dispersed (virtual solubility) and 2) colloid (sol of

silicon acid) (graph 154). Because in literature there are indications that the colloid silicon acid, forming from water stable agregates, is undetectable with the colorimetric methods, Shereshevskaya experimented with this problem; she was interested to clarify if the colloid fraction of the silicon acid exist in the filtrates obtained by her, even though it is not detectable by colorimetric determinations. Therefore she applied methods which should have led to the disruption of the colloid silicon acid(heating with carbonate and caustic alkalis, and also with hydrofluoric acid). After these operations it was not possible to detect a greater quantity of free silicon acid than was possible before the operations. Nor did the application, by the author, of physico-chemical methods allow for the dectectionof colloid silicon acid, in the filtrates, along with small quantities of sedimentary silicon, which were detected in the virtual-solution status, thatis, in the molecularly dispersed form.

Determination of the Absorbability of the Dispersive Phase of Aerosols in an Organism

Aerosol particles, which have settled in the upper respiratory path, lungs and gastrointestinal tract, upon disolving, are subject to an energetic absorption. However, fine dust particles can penetrate between the epithelial cells of the mucous membrane of the upper respiratory paths and lungs into the blood and lymphatic vessels without dissolving.

The absorbability of the dispersed phase of aerosol in the organism has a great hygienic importance, especially in those cases where toxic type dusts are involved, but still few authors have occupied themselves with this problem.

Let us examine the method applied by I. R. Petrov and G. A. Dmitriev for the clarification of this problem.

They conducted their experiments on rabbits; colloid paint- trypan blue, lead salt (acetic acid and nitric acid lead) and indigocarmino (indigotinsulfonate) were tested.

For the study of the absorption from the trachea and nasopharynx area, there was conducted the lowest possible tracheotomy and the trachea was ligatured somewhat above the tracheal apertures. To divert the possibility of the substances, introduced into the trachea, from penetrating into the stomach, ligatures were made on the esophagus. A solution of the trypan blue was introduced into the opening of the trachea with the aid of a blunt needle; from here the solution spread into the nasopharynx and cavities of the mouth and nose.

To study the absorbability from the trachea alone in successive tests, ligatures were placed on the upper part of the trachea as well as on the lower part and tracheotomy was performed; the study was again with trypan blue.

For the study of the absorption from the lungs, a powder of trypan blue or lead salt was blown into the trachea through a trocar.

Finally, for a study of the absorption from the gastrointestinal tract, trypan blue or lead salt in solution form was introduced through a probe into the stomach or into a large intestine through a preliminarily superimposed fistula.

The quanity of trypan blue introduced to the animals fluctuated from 13.3 to 100 mg, and the quantity of lead salt from 272 to 420 mg to 1 kg weight of the animal. The larger amounts were primarily used with introductions into the gastrointestinal tracts.

Determination of trypan blue in the blood was madē with a colormeter 15 and 30 minutes and 1, 2, 3, 6, and 24 hours after introduction. The standard solution of trypan blue was prepared immediately before each test on plasma of blood which was taken from the same animal which was to be tested. The determination of the lead salt was made at those same intervals by electrolytic methods.

Twenty-five tests were conducted in all. Computing the results of the tests, the authors come to the conclusion that the fastest absorption comes from the lungs and the slowest from the gastrointestinal tract with the absorption from the upper respiratory path occupying an average intensity.

Method of Analyzing Phagocytosis of Various Types of Aerosols

In contrast to foreign authors, who studied phagocytosis of aerosol particles in vitro, our authors, approaching this question more correctly and, studying the effect of mediums on phagocytosis, studied the problem in vivo.

To study the phagocytosis of aerosol particles by leukocytes of the blood, E. I. Dobrolubov applied the following method: suspensions of various dusts (coal, quartz and red lead) were injected intravenously to rabbits; the computation of the leukocytes, phagOcytizing the aerosol particles, was done on smears of blood which were examined under a microscope (immersion). On several smears there were counts of 100 polynuclear and a disclosed percentage of cells which contained an incorporation of dust.

The dust suspensions were prepared in the following manner: 5 g. of the given dust were mixed with 50 ml of a physiological solution and then the suspension was poured through a cotton filter several times or

until no dust grains with a size exceed ing 7-10 microns were left. The suspensions were diluted so that the number of dust particles in a unit of volume of fluid was identical; two drops of a solution of gumarabic were added to the suspensions for greater stability.

The author comes to the following conclusions as a result of the data of his experiments.

Absorption of coal particles starts after 10 to 15 minutes. The number of cells phagocytizing dust particles after 30 minutes reaches 12-27%. After this the number grows and readhes a maximum of 20-24 to 50-52% (individual fluctuations) in 65 to 90 minutes. The number of dust particles absorbed by one cell is 2-3, but never more than 5.

The absorption of the quantz particles by leukocytes goes very energetically; after only an hour 52% of the leukocytes contain an incorporation of quartz particles in the protoplasm. Further on, the number of phagocytized forms reaches 60%.

The absorption of the particles of red lead was less energetic; the number of phagocytized forms reached 5-7% in all.

Duting lengthy repeated intravenous introductions of the above dust suspensions, the aerosol particles of the coal, quartz and red lead were never deposited in the Kupffer cells of the liver and were always encountered in the protoplasm of the macrophages of the spleen and in the histocytes of the lungs; the phagocytosis of the coal and quartz was expressed equally, while the phagocytosis of the red lead was weaker in comparison with the coal and quartz.

On the basis of the above, the authors come to the conclusion that the phagocytosis of the lead is subjected to action of the leukocytes of the blood as well as the tissue phagocytes.

I. R. Petrov studied the phagocytosis relavtive to various aerosols in the lungs. The tests were conducted on rabbits; the following dusts were studied; coal, quartz and red lead. In one series of tests the animals were given dusty air to breathe (size of particles no larger than 5-10 microns) for 1-3 hours and the other series- suspensions of dust (except ultramarine) were introduced into the ear vein for 14-45 days, at 5 ml per day. The suspensions of dust were prepared the same way as for the Dobrolubova tests (see above).

After these tests and others the animals were killed; before the opening of the breast cells their trachea was ligatured; the fixation of the lungs and other organs was in fomaline. The mediums were developed in the usual manner. For the evaluation and comparison of the phagocytosis, relative to various dusts, there were conducted computations of the lung phagocytes with an incorporation of dust particles, determinations of the size of the phagocytes and the sizes of the dust particles incorporated in the protoplasm of the cells.

The above tests indicated that during inhalation of various dusts, the coal particles were phagocytized most and the quartz, ultramarine and red lead to a lesser degree. This was also observed after intravenous injections (the uatremarine was not introduced intravenously).

The most expressed hypertrophia of the lung phagocytes was observed after inhalation or intravenous introductions of coal dust; the other dusts, introduced by either method, were expressed less.

After inhaling the dust of red lead and quartz, phagocytization was of particles of 1 micron or smaller; during inhalation of the coal and ultramarine dusts, the greatest percentage of the phagocytized particles were 1 micron and larger.

Method of Analysing Aerosols Produced by Humans Through Speaking, Coughing and Other Physiological Acts

It is known that a person, during conversation, coughing or sneezing, expells from the mouth, and to a lesser degree from the nose, various quantities of minute fluid droplets capable of traveling great distances from the point of expulsion, which stipulates one of the types of aerogenic infections (droplet infection). This fact was first established by a Russian scientist, P. N. Lashchenkov.

The importance of these agents as infectious material depends, on one side, on the degree of their stability and ability to disperse and, on the other hand, on the degree of infection of particles of the dispersed phase by pathogenic microorganisms. These two ideas must be kept in mind during the study of the aeroslol expelled by humans during physical acts if we wish to clarify the question of their capabilities as agents of infections.

The degree of dispersion of the expelled droplet particles, their particle concentration and degree of stability depend on the character of the physiological act and the nature of the expelled particles. The strong expulsion with the act of sneezing causes a greater particle concentration than during coughing and coughing is less than speaking. A viscous mucous secretion gives lesser dispersive particles than saliva under identical conditions.

The degree of dispersion of the particles over a smaller or larger area depends on the kinetic energy transmitted to the droplets at the moment of their expulsion, on the size of the droplets and speed and character of the air waves (currents). Relatively large particles, those with a 1.0 mm diameter, expelled at 46 cm/sec, can travel up to 11 m

from their point of expulsion in quiet air. The spending of the kinetic energy in surmounting the resistance of the air causes a loss in the speed of the droplets and they fall when subjected to the forces of gravity. Fine droplets (0.1 mm or less in diameter) in their movement conform to the basic air currents and can be transferred for great distances. Droplets of a diameter of 0.07 mm remain in a suspended status and follow the air movements during a current of 7.5 m/min and more, and droplets of 0.01 mm diameter are able to remain in a suspended status with air movements of 0.2 m/min. The finer droplets remain in a suspended status in the presence of very light air currents.

Jennison, utilizing the Tindal phenomenon, photographed aerosols expelled by humans from the mouth and nasal areas during sneezing, coughing and speaking. See graph 155.

While studying the photos, having taken a complete series of them, Jennison was able to determine the size of the droplets of the aerosol, distance of their dispersion, length of their location in the air, speed of evaporation and sedimentation. Analogical studies were conducted by Veiraukh and Rzimkovski.

To study the bacterial sowing of the expelled aerosols, there is applied a method called 'Cough disk'. It consists of this: 10-20 cm from the subject used in the test there is placed a Petri vessel with an elective medium and the subject coughs into the direction of the surface of the medium. The covered vessel is placed into a thermostat.

Having detected the origin of the infection of the air, it is possible, by taking a ~~extraction of~~ sample of the aerosol at various distances from the origin, to determine the degree of dissemination of

the infection material. All the above described methods can be used for the selection of samples except the spontaneous sedimentation method.

The later method can be used only with the following conditions: 1) the vessel is filled with an elective medium, 2) the vessel is left open no less than an hour, 3) the air is sprayed before the removal of the vessel covers. There is much foreign and original literature on this subject.

Method of Conducting a Biological Experiment in the Field of Aerosols

The most frequent biological experiments on the effect of aerosols on the organism of an animal are aimed at the clarification of the effect the entrance of the dispersed phases of the aerosls into the lungs and respiratory path; a less important question is about the action of the dispersed phases on the external covering (skin, mucous membrane, fur, etc.).

The tests are ordinarily of a chronic character, but acute tests are also possible with toxic dusts.

Because the animals used as laboratory subjects (rabbits, cats, rats and others) must be healthy before the tests, they are checked for weight, temperature and general condition.

Because the introduction of the aerosol particles through the nasal apertures into the respiratory path of the animals being tested is sometimes difficult, especially with rabbits, the animals are sometimes preliminarily subjected to tracheotomy and the introduction of a tracheotomic tube.

During the experiment there are studied the changes in the behavior and condition of the animal, laboratory analysis of the blood and

excrement, and when convenient, the animal is killed and there are pathologicoanatomical and pathologicohistological studies of the variations in the organism. If the tests are of a bacterial aerosol, then bacteriological analysis is made.

Experiments on the effect of aerosols entering the lungs are done in several ways; a) dust chambers in which the animals are held, b) dust masks which are placed over the face of the animals and c) intratracheal introductions of a suspension of dust particles. These methods are written up below.

Application of the Dust Chamber Method

The chambers are small with a usual capacity of 1 m3. The walls are covered with glass for easier cleaning. The devices used to create the dust in the chambers are located either inside or outside the chamber itself. In the latter case, the flow of dusty air is conducted through tubes into the chamber. During testing the determination of the weight and particle concentration of the dispersive phase, the size of the aerosol particles, etc., is done by collecting samples. The animals are subjected to the chamber for long or short periods of time, and once or many times depending on the problem.

The most difficult problem in creating dust in the chamber is obtaining an even and constant concentration of the aerosol and limiting it to various levels. We will look at the most important suggested answers to this question.

In the physical laboratory of the Moscow Institute of Health the chamber was built on the principle of dynamical balance (equilibrium), with the aid of broken whirlwinds. The chamber is a wooden cube with a capacity of 1 m3, it has three glass walls; the top and floor have

built-in ventilators, run by mot[illegible] [illegible]d producing 5 liters/second. The from wall is removable, with rubber stripping. There are numbered apertures for tubes which control the concentration of the dust.

The wings of the ventilators are 25 cm long and set at a 45 degree angle; and the two fans operate opposite each other.

The work of the chamber was first tested with confetti which was placed on the floor of the chamber. These tests showed thr direction and flow of the air currents in the chamber. The corners of the chamber were rounded-in to afford turning aids for the whirlwinds.

In using dust in the chamber, the dust is first placed on the floor and then the ventilators are allowed to circulate the dust sufficiently to create a concentration of the heavier particles on the floor. The average concentration, according to the authors, is 4%, and is heavier toward the edges of the chamber. The percentage of concentration of dust on the floor can be regulated by the speed of the air currents through the speed of the fans.

Leningrad Institute of Hygiene of Professional Diseases. Prokofev constructed two types of apparatusees for the creation of dust in chambers. Here we will describe the more absolute second type.

The apparatus consists of: 1) an adaptor for the intake and regulation of the inflow of dust, 2) an adaptor for the even agitation of the dust, and 3) an adapter for the trapping, mixing with air and suspension of the dust in the chamber. (Graph 155 and 157).

The intake and regulator consists of a recieving bunker (11) and a bucket chain conveyer. The bunker is for the intake of the powdered material, its capacity is 450 ml. It has a pear-shaped form. The bucket-chain conveyer has the following construction: on the steel

shafts rotating on bearings set in the body of the frame are secured two six-pointed gears, one below and one above (8 and 9 on 156). The frame of the device is secured to a slab which in turn is secured to a table or floor. Two chains move along the gears and on each chain is a bucket which is removable (7). The conveyer is covered with the top cover of glass to allow observation of it's performance.

The device for the even dispersion and mixing of the dust is as follows: the dust from the buckets spills onto an inclined platform (23) which is activated by the knobs (14) embedded in a disk (15). This shaking insures an even spilling of the dust into the funnel which leads into the dust-air mixing chamber.

The walls of the funnel are movable (32) which allows for the control of the flow of the dust. The dust falls into the small bunker (12) from the funnel if it is not used. The dust can be removed from here for repeated use.

The device for lifting up the dust, mixing it with air and delivering it into the chamber is as follows: The dust from the inlet funnel is carried into the suction chamber of the gas-jet ejector (3) from where it is carried by a strong fast air stream from the nozzle of the jet of the ejector (4) and then goes into the diffuser (1) and into chamber. To seperate the heavier fractions of dust from the air, it can be directed through a settling tank. Depending on the demands of concentration, the air can be mixed; dusty air with filtered air coming from the jet nozzle. Illustrations 156 and 157 are of a machine which [illegible] good results.

The regulation of the concentration of the dust can be done with the number of buckets used, the size of the inlet funnel, the addition

of filtered air and with the settling tank. The settling tank is not shown on the illustrations.

Regulation of the size of the dust particles entering the chamber is controlled by the line speed of the stream of dusty air entering the settling tank and chamber.

The constancy of the concentration and size of the dust particles in the chamber itself is attained with the location of the inlets and outlets and also with the aid of a fan located in the chamber. Also, correct feeding of the device is important: a) the buckets must be filled evenly, and b) the dust must be shaken off the shaker platform (29) before the next bucket of dust is dumped on it.

A beater which struck the side of the initial bunker from time to time was added during the testing of tobacco dust to avert clogging.

Kiev Institute of Hygiene of Professional diseases used the G.K. Shakhbazyan and E. I. Spen device (159) for the study of dusts.

The device on illustration 159 is as follows: the hopper (8(has a cylindrical form with cone shaped ends; capacity of it is 450 liters. Four sleeves (boxes)(12) lead to the outside of the chamber. The animal is placed in a wooden box (13) which is set into the sleeve. The boxes are so constructed tant only the head of the animal remains outside. Four windows(9) in the chamber allow for observation of the behavior of the animal during testing. Four outlets (valves)(14) are used to sample the air.

The air is forced by a fan (1) into two lines (2)(3), one being the main line and the other an accessory. The volume of air is controlled by the two gas meters (2-3), which also help control the speed, meters of air a minute and evenness. From the gas meters the air goes

to the dust feeder (4) where the air is mixed with the dusty air. Then the air goes into a settling chamber (not shown) and then into the main line. This is where, in case of necessity, clean air from meter 3 can be mixed to the dusty air to control concentration. The main line devides into four lines before entering the chamber (7).

The even concentration of the dust indide the chamber is done with an electric fan situated in the bottom of the chamber (not visible on graph). The air leaves the chamber through tube 10.

The dust feeder is shown on illustration 160. The dust is loaded into the cone shaped opening to the graduated hopper (10) with a capacity of 55 ml which is prepared of plexiglass and aids in the control of the incoming substances. The dust then falls onto the auger(1), the speed of which can be regulated.

The rotations of the auger carry the dust along a horizontal cylinder (2) into the injector. The injector has an incoming nozzle(6), a chamber (5) and an outgoing nozzle (7). The air coming through the (6) nozzle carries the dust particles through the (7) nozzle out into the main line which leads into the chamber.

The rate of the dust feeder is controlled by variation of the number of rotations per munute of the auger. The auger is driven by an asynchronous three-phase motor (6(graph 159) through a reductor (5(graph 159) and a rachet gear with variable speeds, all of which aid to control the speed of the auger.

Application of the Dust Mask Method

Recently E. V. Zhukhrina described the following method of individual introductions of dust to animals. The face of the animal is put

into a glass mask through which is suctioned dusty air (graph 161). The animal being tested usually rabbit) is placed into a box with only its head outside. The mask (3) has two tubes; one is for the dusty air entering the mask from the dust feeder (2) and the other leads from the mask into an adapter with cotton filters and from there throught the rheometer (5) and suction device (6). The rheometer (5) measures the volume of air going through the mask. The other rheometer(1) is used only for a short time as a check of the fit of the mask (if valve (b) on the line leading to the dust feeder is closed and air is suctioned through the whole system with valve (a) open, then both rheometers should read almost identical).

The control of the concentration of the dust is done with valves (a) and (b). These regulate the free (filtered) air and the dusty air flows.

To determine the concentration of the dust in the system the following procedure is followed: the dust feeder is weighted before and after the test, the decrease in weight is the amount of dust which has passed through the system. This quantity is divided by the volume of air which also has passed through this system at the same time to arrive at the concentration which is expressed mg/m3. Conducting such readings regularly helps to determine the constancy of the concentration. This method is highly recommended for all types of dusts, especially not for toxic types.

The Intratracheal Introductions of Suspensions of Dust Particles

This method was applied by M. G. Ivanov, E. M. Gorodenski and many others.

For this method a blunt needle is inserted into the trachea through the mouth and throat. The completion of the method is as follows: the subjected to a light ether narcosis and is placed on its spine with its mouth wide open and tongue drawn out to the extreme. The blunt needle is secured to a syringe filled with a physiological solution(1ml) and the needle is then inserted down the center of the mouth, past obstructions until it enters the trachea. If the needle is in position in the trachea, a pull on the plunger will draw air into the syringe; a false position will give a negative pressure when the plunger is pulled. When the correct position is ascertained, the syringe with the physiological solution is exchanged for one containing an exacting quantity of the suspension being tested, and the suspension is energetically forced into the trachea.

The described method is bloodless and sterile; with some practice this should take only one minute. Usually the animal awakens from the narcosis immediately after the operation. White rats accept 1 ml of fluid easily; after several deep inhalations they breath normally.

Means of Obtaining Artificial Smoke

There are various methods of artificially obtaining smoke for study. a) The lighting of a substance (coal, tobacco, magnesium, etc.) which causes smoke. b) Sublimation of an easily volatile hard substance, the fumes of which, mixing with the cool air, concentrate and form smoke, as with sublimation of ammonium chloride (NH_4Cl). (NH_4Cl may form NH_3 and HCl at first, but recombines almost fully to NH_4Cl). c) Passing of air through a heated solid or fluid body which is distinguished with a little volatility; during this the air is saturated

with fumes of the heated substance, and with the cooling of the air, part of the fumes come out as aerosols. Highly dispersive aerosols of anthracene can be obtained this way, also aerosols of diphenylamine, orthophthalic acid, stearic acid, paraffine and others. Also in this category: Chemical interaction between substances, a result of which produces an aerosol; as interaction between rarification of the air with ammonia and hydrogen-chloride; action of atmospheric air on fumes of zinc-ethyl, which have been mixed with some inert gas (nitrogen), and others. d) The original method of obtaining aerosols with a big concentration was developed by N. S. Smirnov. By this method, two substances with a great differnece in their boiling points, as glycerine (boiling point-plus 290 C.) and liquid air (minus 194.4 C.) are used. The high boiling sustance (here glycerine) playing the role of the vapor-generator, should be heated somewhat and then the low boiling substance (here liquid air) should be poured on its surface. The liquid air, having come in contact with a super hot surface of the glycerine instantaneously breaks into a great number of fine droplers -- spheroids, simmilarly to the formation of spheroids when water contacts the surface of heated metal. Under the pressure of the liquified air, under each droplet, there are formed depressions on the surface of the glycerine. From the cavities there are expelled streams of vapor like glycerine which blends into a general flow while mixing with the air. With the above method the author obtained vapors of oleic acid, salol, machine and transformer oils. e) Recently Sinkler and Lamer published a method of obtaining aerosols with a high degree of iso-dispersion. We will apply the method to substances with a boiling temperature of 300-500 degrees C. (oleic and stearic acid, triphenyl

and tricresylphosphate, colophony, menthol and others). The substance is heated in a two-liter flask to 100-200 degrees C. and then filtered air is passed through it at the rate of 1-4 liters/minute. Air containing artificially created nuclei of condensation, resulting from a spark discharge or heating of sodium chloride, is simultaneously directed into the flask. The mixture of air , vapors of the heated substance and nuclei of condensation are put into a superheater which has been preheated to 300 C., where evaporation of sprays of the liquid takes place and then a final mixing after which the mixture is put in a vertical tube which is 50 cm long and with double walls. Here, owing to the slowness of the cooling, condensation of the vapors takes place only on the nuclei.. The aerosol coming from the tube is mixed with air to decrease the effect of coagulation. The degree of dispersion of the particles of the obtained aerosol is uniform; the sizes of the particles vary no more than 10% from the average size. Varying the temperature of evaporation, speed of air passage and number of nuclei of condensation, it is possible to vary the dispersion of the aerosols to a great extent. f) Oil vapors can be obtained by heatinf an oil in a stove with a later rarefication of the oil vapors with streams of cold air which causes a supersaturation and the formation of aerosol. I. S. Artemov constructed a special apparatus for this process (graph 162). The metal electric stove (1) is connected with a T-box (2) with the aid of an asbestos stopper. The branch box (T-box) is equipped with a metal tube 40 cm long and 3 cm in diameter and is partitioned from the stove by a shield (3). During tests the tube is cooled by a stream of cold air. The heating unit is equipped with three metal tubes (4), (5) and (6). A thermometer (7) with readings to 500 degrees C is built-in-to tube (4). Onto tube (5) there is placed a glass tube with the

the rubber stopper (9) holding a microburet. The glass tube is held in position by asbestos and liquid glass (8). Oil with an accurate measurement to 0.01 ml is directed into the unit through the microburet. The oil falls on the disk (11), heated to 230 degrees C. Air heated to 230 degree and filtered is fed into the unit through tube (6) at the speed of 0.2 l/min. Here the air is mixed with the vapors of the oil and the mixture then enters the T-junction and in a long tube is rarefied by streams of cold air which causes the formation of an aerosol. g) Vapors of metal can be obtained with a voltaic arc or an electric stove(graph 163). Smokes, consisting of oxides, are form from the oxidation of the metals. Exceptions are platinum, gold and silver. Mixing the forming vapors with air causes a quick condensation.

IDENTIFICATION OF ORGANIC TYPE DUSTS T. 15

Part one; see next page..........

Type of dust → / Reactives ↓	Wool	Silk	Linen	Hemp
Ammonia solutions of cupric oxide I	Swells during heating, but does not dissolve	Easyly, evenly dissolves	Swells evenly without blisters, then dissolves fully	Noticable swelling, uneven, places only some particles dye a green color.
Solution of chloride zinciod	No noticable variation		Dyes blue with swelling in places of displacement	No visible variation.1
a) 1-2 drops of distilled water added	Same	Same	Blue color remains	Same
b) a large quantity of distilled water added	Same	Same	Swelling slower, color varies from red-violet to claret.	Same
Chloride zinc(concentrated solution acidified	Severe swelling; lamination of fibers protrudes more even onto the dyed types	Severe swelling	-------	Fiber swells, besides lignigied, and particles of tow also
Sulfuric acid aniline	Does not dye color		Does not dye. X 2	Dyes lemon-yellow
Solution of oxide in caustic soda	Dyes brown during heating	No dying	----	------
Spirit tincture of alkanna root	Same	Same	Does not dye	Dyes lemon yellow color

1. Particles of hemp and jute dust, subjected to a preparation working of a 10% solution of nitric acid with potassium chlorate, by which we were able to remove the incrusting substances, with chloride zinciod there is a violet dye.

2. The particles of linen dust can give a green color after a long time; the particles of linen, after the action of HSI?, that is, after bleaching, they do not dye after sulfuric acid aniline.

T.13

Part two; see previous page;;;;;;;;;

Jute	Cotton	Woody	Cork	Paper
No different from hemp	Swells, causing bubble like inflation, retaining cuticul in form of glassy pellicle	Dyes yellow color	Shows no visable action	dissolves
No visable action. 1	Dyes blue	----	No visable change	Dyes dark-blue
Same	Turns light-sky-blue	----	Same	---
Same	Turns bluish violet color	----	Same	----
Almost no action	Dissolves	----	Same	Causes running of particles. From the addition of water by drops, there results flocculent residue.
Dyes	Does not dye	Dyes lemon-yellow color	No color noted	Does not color. 3
--	--	--	--	--
Dyes	Does not dye	Dyes lemon-yellow color	Dyes clear-red color	----

3. Particles of paper dust can be dyed with sulfuric acid aniline, if there is woody cellulose in the paper....

Table 16
Compartiive characteristics of aspiration of air by the human and mechanical respiratory apparatuses

Type of aspiration apparatus	How apparatus completes aspiration	Quantity of air aspirated in [illegible] second	Nega pressure, in mm of a water column	Air movement speed in the filter aperature. cm/sec	Conditions changing action of aspiration appar
Human respiratory apparatus	Discontinuously, with frequent intervals	350-400 ml/sec	10-120	18.75-36.75	Repose and work. Meteorological conditions. Individual peculiarities
Petri pump(cylinder capacity)350ml)	Discontinuously, with frequent intervals	300 ml(average speed)	30-70	31.1	Capacity of cylinder. Operating speed.
Bellows(capacity 350 ml)	Same as Petri pump	250-300ml at average operating speed	15-70	27.5	Capacity and speed
Water-jet pump	Continuously	60-70 ml at pressure in supply-line in 2.5-3 atmosphere and dia. of outlet 6-7 mm.	2-3	9.75	Positive pressure in supply-line. Size of oulet. Quantity of water, flowing out in unit of time
Glass cylinder (capacity 5Χ1)	Discontinuously, with sparse intervals	30-35 ml(cylinder emptying in 2-3 minutes	1-2	4.8	Capacity of bottle Height of connecting tube. Size of outlet.
Reversing apirator(capacity 5 1)	Discontinuously, with sparse intervals	10-15 ml(emptying of cylinder in 5-9 minutes)	0.5-1	2.4	Capacity of cylinder. Size of oulet aperature

2-1

Table 17.

Sprectrum of Dispersion of Aerosol Particles of Tabacco and Foundry Dust, Inhaled by Man during Light Work.

Dust	Percentage of entrapment of aerosol particles by size (in microns).				
	1	1-2	2-3	3-5	5-10
Tabacco dust	35.2	45.3	14.5	4.2	0.8
Foundry dust	34.9	59.8	4.8	0.3	0.2

Table 18.

Solubility of Several Types of Aerosols.

Type of aerosol	Degree of solubility	Type of aerosol	Degree of solubility
		Powdered brick	Barely
Glass	Little	Table salt	Fully
Metal and steel filings	Fairly well	Sodium carbonate	"
		Quicklime	"
Limestone, marble....	Quite well	Chromic acid potassium	"
Granite	Barely	Mother-of-pearl	Little
Sand	"		
Feldspar	"	Charcoal	Some
Porcelain	"	Wood	Little
Thomas slag	Fairly well	Fem, lenen, cotton	Very well
Lead	Well		
White lead	"	Horse hair, feathers	Little
Zinc oxide	"		
Cement	"	Silk	Very little
Clay	Barely	Hide(Leather)	" "
Gypsum	Well	Fur	" "
English Red-Fe_2O_3	Barely	Flour	Fairly Well
		Coal	Somewhat
Copper	Well	Brown coal	Barely
Brass	Well	Sugar	Easyly

b. Translation of graphs and illustrations preceeding.

Graph 144. Shafir apparatus for the microbiological analysis of the air.

1- electric motor, 2-shock absorbers, 3-metal bucket, 4- glass cylinder, 5-removable metal housing, 6- metal air-supply tube, 7- nut, 8- thrust collar, 9- gasket ring, 10- supporting ring of housing, 11 screws, which tighten gage to micromanometer, 12- adjusting bolts, 13- level, 14- circular form used for computing bacteria, it has squares, 15- micromanometer, 16- slide valves for regulation of incoming air.

Graph 145. Krotova appartus.
1- body of apparatus, 2- base, 3- electric motor, 4- ventilator, 5- impeller, 6- disk, 7- springs, 8- Petri vessel, 9- cover of apparatus, 10- cast on locks, 11- disk of plexiglass, 12- cuneiform apertures, 13- threaded ring, 14- sleeve with diaphragm, 15- lead off tube.

Graph 146. Device for the determination of the microbe flora in the air according to Milyavski.

a- Zeittsa apparatus, b- Bunsen flask, c- rheometer, 1- to aspirator.

Graph 147. Dyakonova apparatus. a-and b-cotton filters in ends of tubes, c- control cotton filter.

Graph 148. Shtrauss Apparatus. A- cylinder, b- lead off tube, c- ground pipet.

Graph 149. Rechmenski aerocentrifuge. a- disk, b- fan(without blades, c-glass tube, d- rheostat.

Graph 150. Authors device for the determination of the weight quantity of the dispersive phase of an aerosol inhaled by man.

A- Glass tube for filter, B- drum(chamber), C- nasal adaptors.

Graph 151. Device explained in graph 150 in use.

Graph 152. Scheme of the Vigdorchik and Petrova mask for the selection of samples of inhaled and exhaled air.

N-and N1- valves, M- and M1- mica disks, K- tube, connecting mask with Owens-1 apparatus, n- and n1- aperatures, Z- handle for moving of disk.

b.. (con't) Trans.graphs and illustrations.

Graph 153. E. N. Vigdorchik device for the determination of the number of smoke particles entrapped in the repiratory path and lungs upon breathing.

M- mask,,U1, S1,and O1- microscopes, drain and illumination for the computation of the ultramicrons of inhaled air,,, U2, S2, O2- as above, but for exhaled air, H1- and H2- valves for the selection of samples from the chamber into the computor, B- rheometer, D- connecting tube, T- transformer, R- rheostat, t- termometer, G- galvanometer.

Graph 154. Electronograms of sol SiO2.

1- visible colloid particles SiO2. 2- visible film with cracks on it, formed during drying of virtual-solution SiO2.

Graph 155. Photograph of aerosol, expelled by a human while sneezing.

Graph 156. Lengthwise cut of apparatus used to creat dust in a chamber. (laboratory of aerosols Lengorzdrovotdela Instute of hygiene (and prof-diseases)

Graph 157. Cross-cut of apparatus for the creation of dust in a chamber.(as graph 156)

Graph 158. Scheme of creating dust in a chamber(see 156 and 157)

1- chamber, 2- and 3- rheometer, 4- and 5- sedimentation tanks, 6- manometer, 7- motor, 8- rheostat, 9- hopper, 10- ejector(pump).

Graph 159. Scheme of device, constructed by G. X. Shakhbazyan and E. I. Spen, for study of manufactured dust.

1- blower, 2- and 3- gas meters, 4- dust input, 5- reductor, 6- non-synchronous three-phase motor, 7- branch lines, 8- chamber, 9- window, 10- lead-off pipe, 11- position of animal in box, 12- sleeve of chamber, 13- wooden box for animal, 14- branch pipe for selection of air samples.

Graph 160. See 159.

1- auger, 2- auger body, 3- counter nut, 4- regulating bushing, 5- body of injecttor, 6- inlet nozzle, 7- out let nozzle, 8- screw, 9- cover of hopper, 10- hopper, 11- nut, 12- tube, 13- special nut, 14- T-piece, 15- bolt, 16- base, 17- hub of auger, 18- hub nut.

b-......

b.. (con't) Trans. graphs and Illus.

Graph 161. Device for the introduction of dust into the respiratory path and lungs with a dust mask according to Khukhrina.

1- and 5- rheometers, 2- dust disperser, 3- mask, 4- filter, 6- dust suctioner.

Graph 162. Artemov apparatus for obtaining oil sprays.

1- metal stove, 2- T-piece, 3- screen(shield), 4- 5- and 6- metal tubes, 7- thermometer, 8- glass tube, 9- rubber stopper, 10- microburet, 11- disk for the heating of the oil.

Graph 183. Obtaining fumes of metal with the aid of an electric stove.

b.....

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INDEX (Con't)